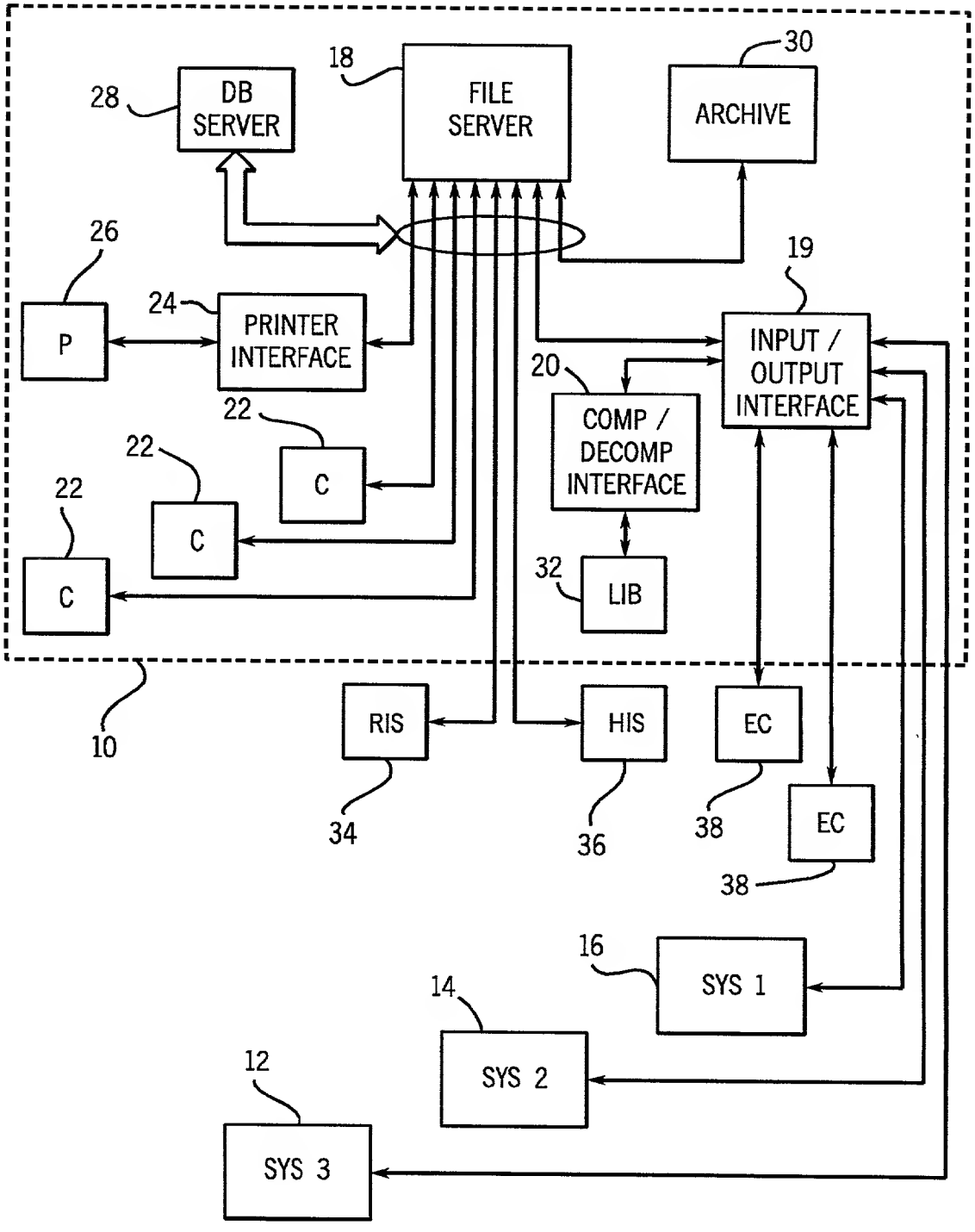

18
FILE SERVER
28
DB SERVER
30
ARCHIVE
26
P
24
PRINTER INTERFACE
19
INPUT / OUTPUT INTERFACE
20
COMP / DECOMP INTERFACE
22
C
22
C
22
C
32
LIB
10
RIS
HIS
EC
34
36
38
EC
38
16
SYS 1
14
SYS 2
12
SYS 3

FIG. 1

FIG. 2

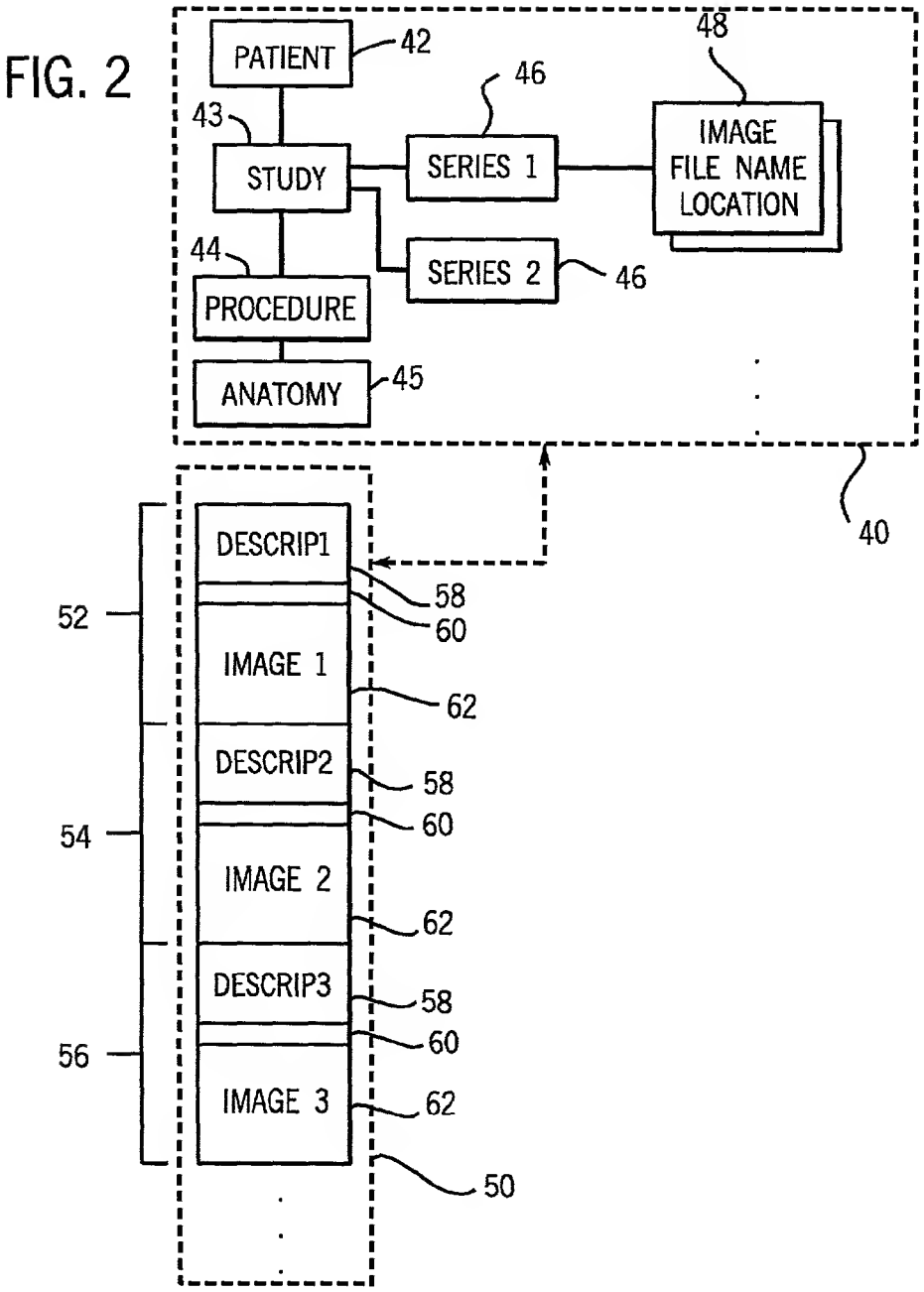

PATIENT
42
48
46
43
STUDY
SERIES 1
IMAGE
FILE NAME
LOCATION
44
SERIES 2
46
PROCEDURE
ANATOMY
45
40
DESCRIP1
58
60
52
IMAGE 1
62
DESCRIP2
58
54
60
IMAGE 2
62
DESCRIP3
58
60
56
IMAGE 3
62
50

FIG. 3

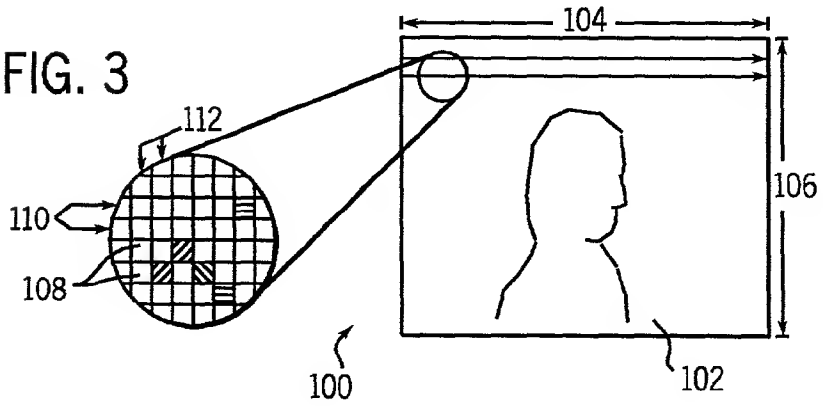

104
112
110
106
108
100
102

FIG. 4

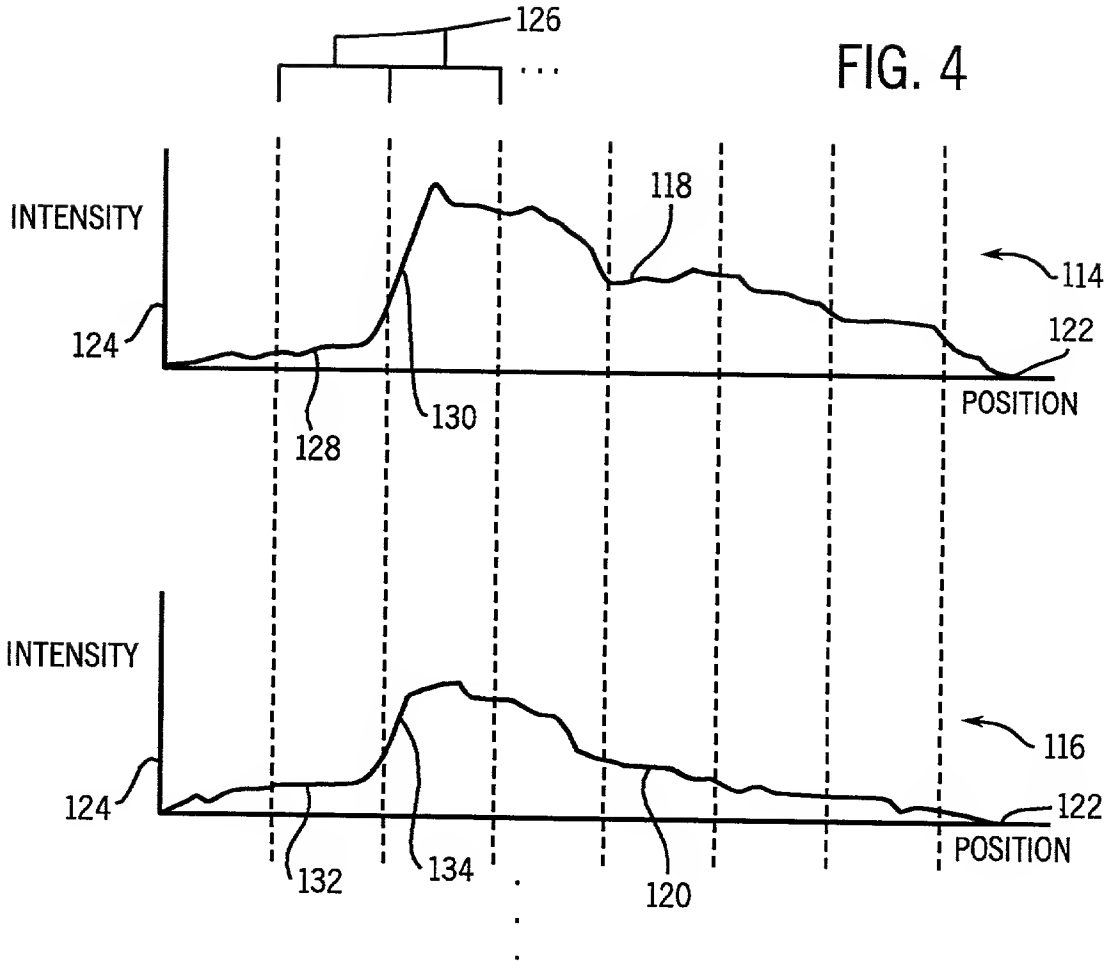
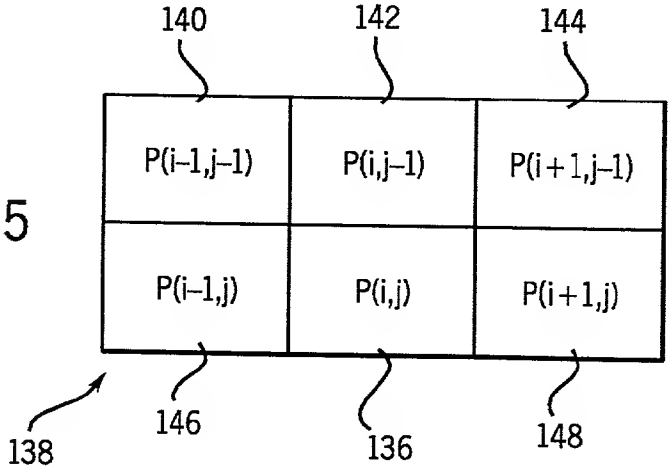

126
INTENSITY
118
114
124
122
POSITION
128
130
INTENSITY
116
124
122
POSITION
132
134
120

FIG. 5


140
142
144
P(i–1,j–1)
P(i,j–1)
P(i+1,j–1)
P(i–1,j)
P(i,j)
P(i+1,j)
138
146
136
148

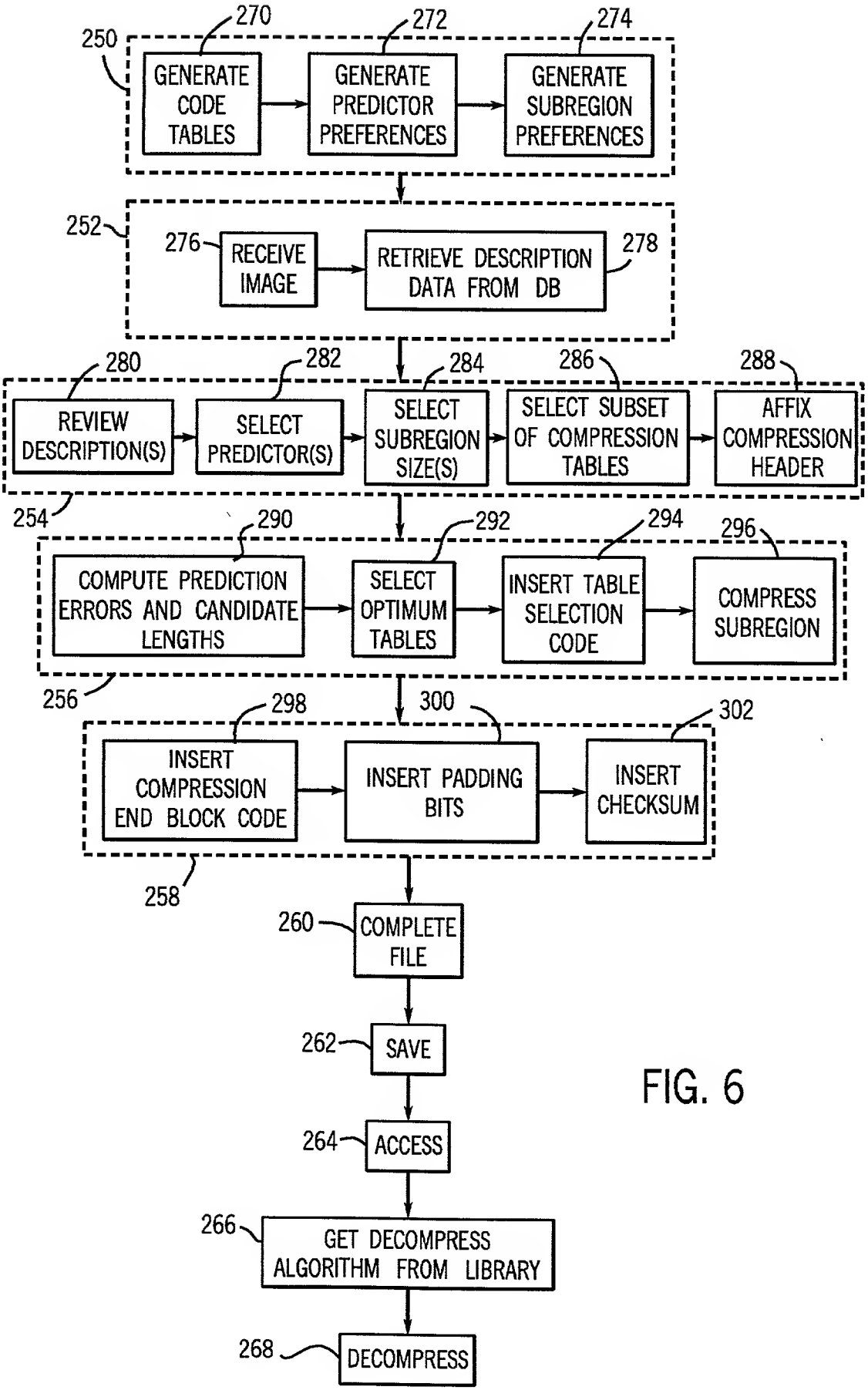

250
270
GENERATE CODE TABLES
272
GENERATE PREDICTOR PREFERENCES
274
GENERATE SUBREGION PREFERENCES
252
276
RECEIVE IMAGE
RETRIEVE DESCRIPTION DATA FROM DB
278
280
REVIEW DESCRIPTION(S)
282
SELECT PREDICTOR(S)
284
SELECT SUBREGION SIZE(S)
286
SELECT SUBSET OF COMPRESSION TABLES
288
AFFIX COMPRESSION HEADER
254
290
COMPUTE PREDICTION ERRORS AND CANDIDATE LENGTHS
292
SELECT OPTIMUM TABLES
294
INSERT TABLE SELECTION CODE
296
COMPRESS SUBREGION
256
298
INSERT COMPRESSION END BLOCK CODE
300
INSERT PADDING BITS
302
INSERT CHECKSUM
258
260
COMPLETE FILE
262
SAVE
264
ACCESS
266
GET DECOMPRESS ALGORITHM FROM LIBRARY
268
DECOMPRESS

FIG. 6

FIG. 7

16 – BIT LOSSLESS ENCODING
SCHEME 0 – MAX RATIO = 16:1

HUFFMAN CODE PREFIX	CODE EXTENSION	DIFFERENCE d	CODE LENGTH	ENCODED RANGE WIDTH
0		0	1	0
100		+1	3	+1
101		–1	3	
1100	X	+2 TO +3	5	+2
1101	X	–2 TO –3	5	
11100	XX	+4 TO +7	7	+4
11101	XX	–4 TO –7	7	
111100	XXX	+8 TO +15	9	+8
111101	XXX	–8 TO –15	9	
1111100	XXXX	+16 TO +31	11	+16
1111101	XXXX	–16 TO –31	11	
11111100	XXXXX	+32 TO +63	13	+32
11111101	XXXXX	–32 TO –61	13	
111111100	XXXXXX	+64 TO +127	15	+64
111111101	XXXXXX	–64 TO –127	15	
1111111100	XXXXXXX	+128 TO +255	17	+128
1111111101	XXXXXXX	–128 TO –255	17	
11111111100	XXXXXXXX	+256 TO +511	19	+256
11111111101	XXXXXXXX	–256 TO –511	19	
11111111110 <16 BITS)		ACTUAL VALUE	27	
11111111111		END OF BLOCK	11	

180, 170, 182, 172, 174, 176, 178

FIG. 8

SCHEME 1 – MAX RATIO = 5.33:1

HUFFMAN CODE PREFIX	CODE EXTENSION	DIFFERENCE d	CODE LENGTH	ENCODED RANGE WIDTH
00	X	0 TO +1	3	1
01	X	–1 TO –2	3	
100	XX	+2 TO +5	5	+4
101	XX	–3 TO –6	5	
1100	XXX	+6 TO +13	7	+8
1101	XXX	–7 TO –14	7	
11100	XXXX	+14 TO +29	9	+16
11101	XXXX	–15 TO –30	9	
111100	XXXXX	+30 TO +61	11	+32
111101	XXXXX	–31 TO –62	11	
1111100	XXXXXX	+62 TO +125	13	+64
1111101	XXXXXX	–63 TO –126	13	
11111100	XXXXXXX	+126 TO +253	15	+128
11111101	XXXXXXX	–127 TO –254	15	
111111100	XXXXXXXX	+254 TO +509	17	+256
111111101	XXXXXXXX	–255 TO –510	17	
1111111100	XXXXXXXXX	+510 TO +1021	19	+512
1111111101	XXXXXXXXX	–511 TO –1022	19	
1111111110 <16 BITS)		ACTUAL VALUE	26	
1111111111		END OF BLOCK	10	

184

FIG. 9

SCHEME 2 – MAX RATIO = 4:1

HUFFMAN CODE PREFIX	CODE EXTENSION	DIFFERENCE d	CODE LENGTH	ENCODED RANGE WIDTH
00	XX	0 TO +3	4	3 ← 186
01	XX	–1 TO –4	4	
100	XXX	+4 TO +11	6	+8
101	XXX	–5 TO –12	6	
1100	XXXX	+12 TO +27	8	+16
1101	XXXX	–13 TO –28	8	
11100	XXXXX	+28 TO +59	10	+32
11101	XXXXX	–29 TO –60	10	
111100	XXXXXX	+60 TO +123	12	+64
111101	XXXXXX	–61 TO –124	12	
1111100	XXXXXXX	+124 TO +251	14	+128
1111101	XXXXXXX	–125 TO –252	14	
11111100	XXXXXXXX	+252 TO +507	16	+256
11111101	XXXXXXXX	–253 TO –508	16	
111111100	XXXXXXXXX	+508 TO +1019	18	+512
111111101	XXXXXXXXX	–509 TO –1020	18	
111111110 <16 BITS)		ACTUAL VALUE	25	
111111111		END OF BLOCK	9	

FIG. 10

SCHEME 3 – MAX RATIO = 3.2:1

HUFFMAN CODE PREFIX	CODE EXTENSION	DIFFERENCE d	CODE LENGTH	ENCODED RANGE WIDTH
00	XXX	0 TO +7	5	7 ← 188
01	XXX	–1 TO –8	5	
100	XXXX	+8 TO +23	7	+16
101	XXXX	–9 TO –24	7	
1100	XXXXX	+24 TO +55	9	+32
1101	XXXXX	–25 TO –56	9	
11100	XXXXXX	+56 TO +119	11	+64
11101	XXXXXX	–57 TO –120	11	
111100	XXXXXXX	+120 TO +247	13	+128
111101	XXXXXXX	–121 TO –248	13	
1111100	XXXXXXXX	+248 TO +503	15	+256
1111101	XXXXXXXX	–249 TO –504	15	
11111100	XXXXXXXXX	+504 TO +1015	17	+512
11111101	XXXXXXXXX	–505 TO –1016	17	
11111110 <16 BITS)		ACTUAL VALUE	24	
11111111		END OF BLOCK	8	

FIG. 11

SCHEME 4 - MAX RATIO = 2.67:1

HUFFMAN CODE PREFIX	CODE EXTENSION	DIFFERENCE d	CODE LENGTH	ENCODED RANGE WIDTH
00	XXXX	0 TO +15	6	15
01	XXXX	-1 TO -16	6	
100	XXXXX	+16 TO +47	8	+32
101	XXXXX	-17 TO -48	8	
1100	XXXXXX	+48 TO +111	10	+64
1101	XXXXXX	-49 TO -112	10	
11100	XXXXXXX	+112 TO +239	12	+128
11101	XXXXXXX	-113 TO -240	12	
111100	XXXXXXXX	+240 TO +495	14	+256
111101	XXXXXXXX	-241 TO -496	14	
1111100	XXXXXXXXX	+496 TO +1007	16	+512
1111101	XXXXXXXXX	-497 TO -1008	16	
1111110 <16 BITS)		ACTUAL VALUE	23	
1111111		END OF BLOCK	7	

190

FIG. 12

SCHEME 5 - MAX RATIO = 2.29:1

HUFFMAN CODE PREFIX	CODE EXTENSION	DIFFERENCE d	CODE LENGTH	ENCODED RANGE WIDTH
00	XXXXX	0 TO +31	7	31
01	XXXXX	-1 TO -32	7	
100	XXXXXX	+32 TO +95	9	+64
101	XXXXXX	-33 TO -96	9	
1100	XXXXXXX	+96 TO +223	11	+128
1101	XXXXXXX	-97 TO -224	11	
11100	XXXXXXXX	+224 TO +479	13	+256
11101	XXXXXXXX	-225 TO -480	13	
111100	XXXXXXXX	+480 TO +991	15	+512
111101	XXXXXXXX	-481 TO -992	15	
111110 <16 BITS)		ACTUAL VALUE	22	
111111		END OF BLOCK	6	

192

Document = 4405404

PATENT 10259603

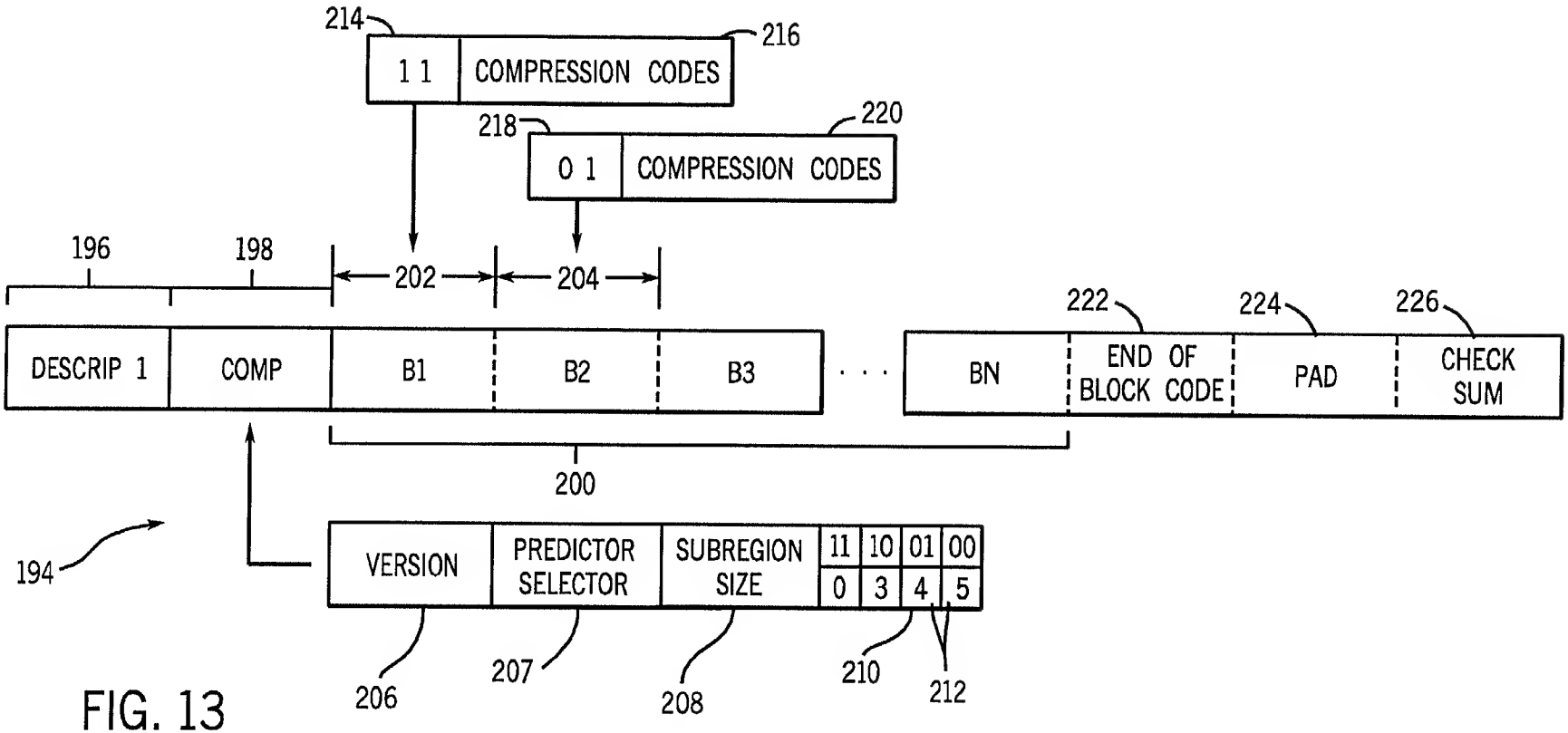


FIG. 13

FIG. 14

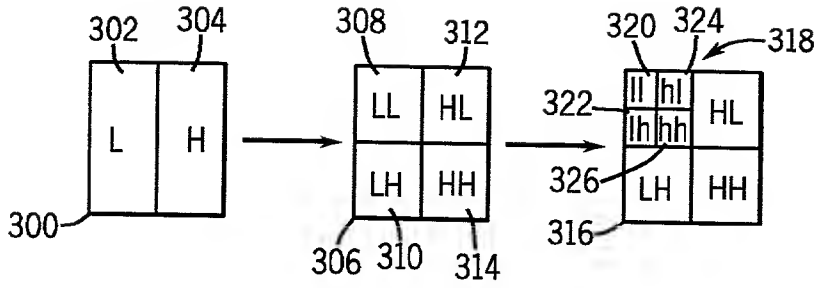
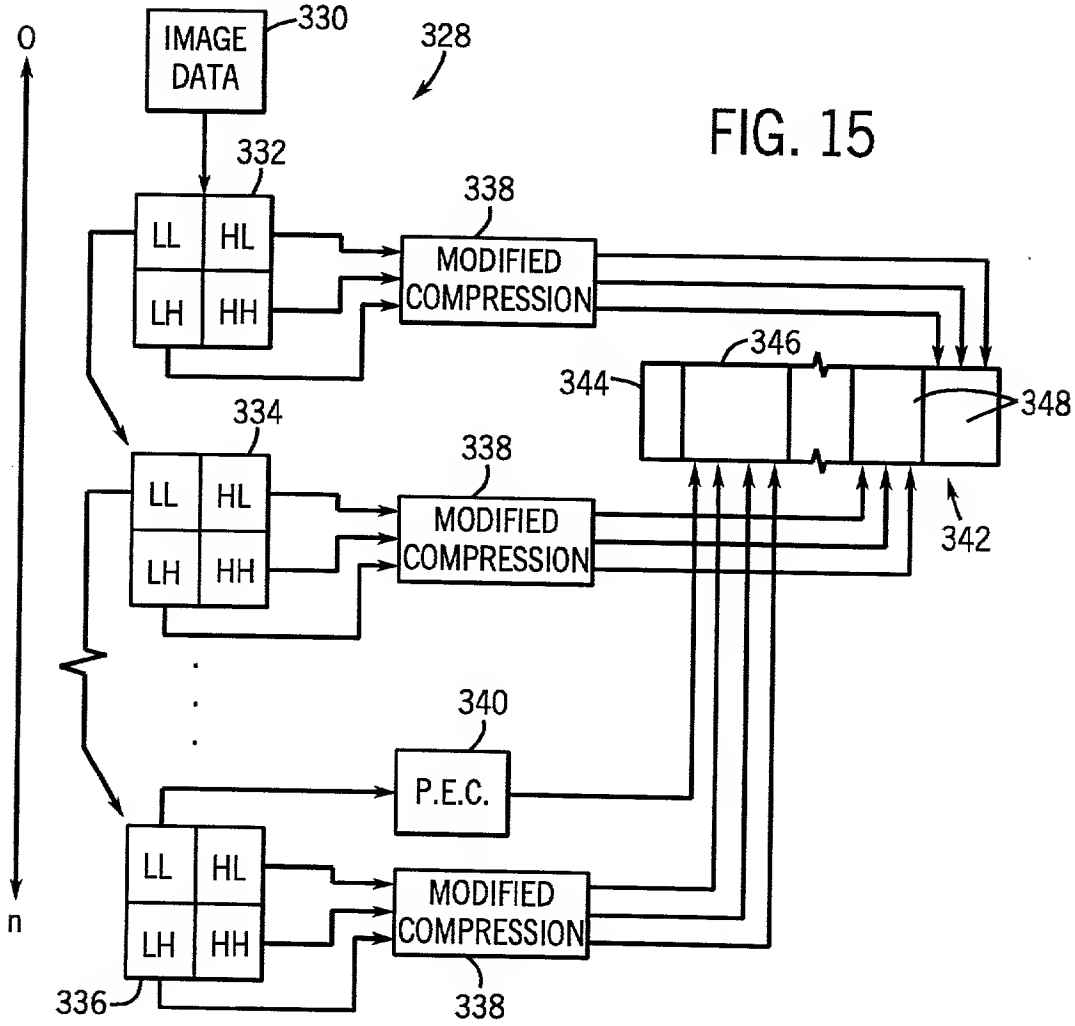

302
304
L
H
300
308
312
LL
HL
LH
HH
306
310
314
320
324
318
322
ll
hl
lh
hh
HL
326
LH
HH
316

FIG. 15


0
n
IMAGE DATA
330
328
332
LL
HL
LH
HH
338
MODIFIED COMPRESSION
346
344
348
334
342
340
P.E.C.
336

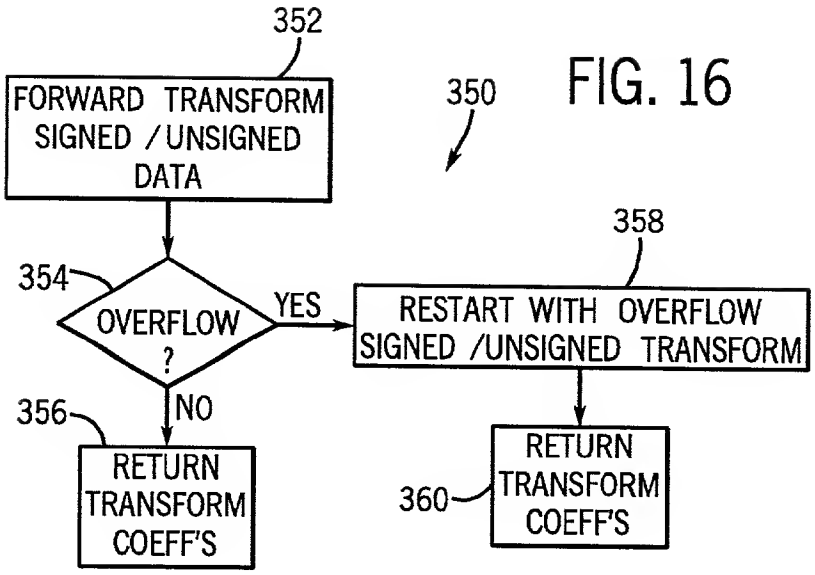

352
FORWARD TRANSFORM SIGNED / UNSIGNED DATA
350
354
OVERFLOW ?
YES
358
RESTART WITH OVERFLOW SIGNED /UNSIGNED TRANSFORM
NO
356
RETURN TRANSFORM COEFF'S
360
RETURN TRANSFORM COEFF'S

FIG. 16

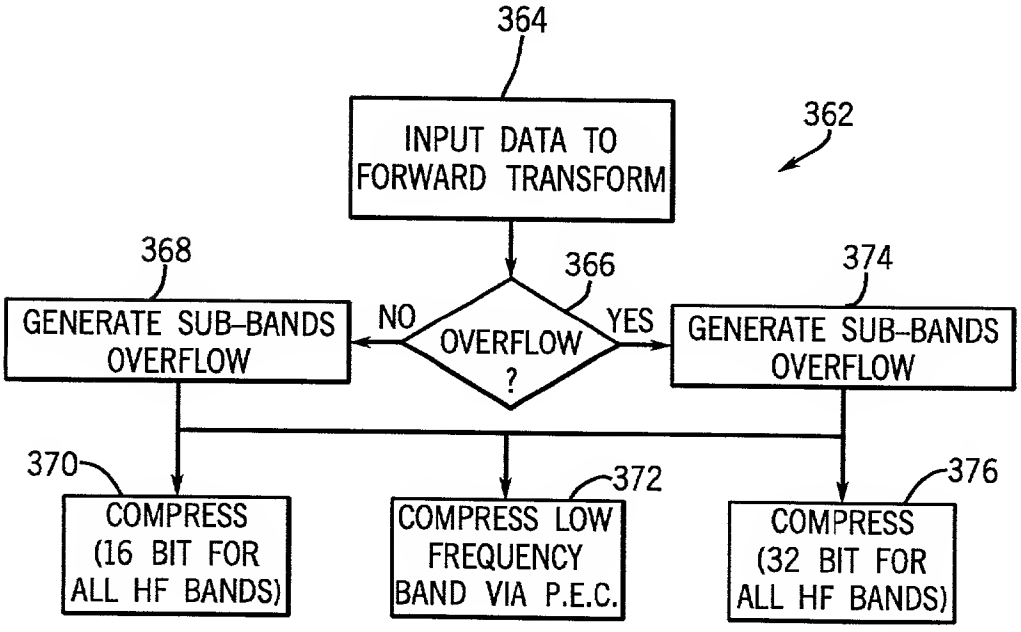
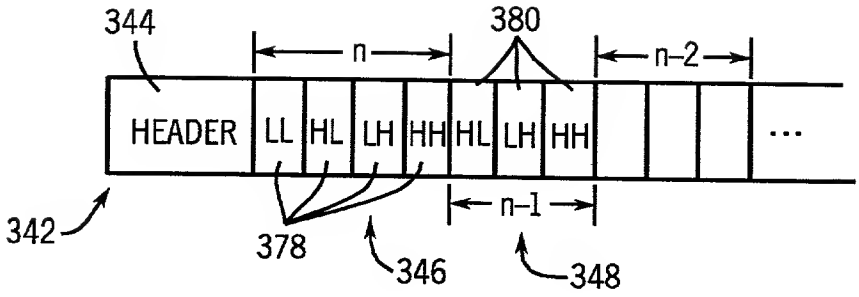

364
INPUT DATA TO FORWARD TRANSFORM
362
368
GENERATE SUB-BANDS OVERFLOW
NO
366
OVERFLOW ?
YES
374
GENERATE SUB-BANDS OVERFLOW
370
COMPRESS (16 BIT FOR ALL HF BANDS)
372
COMPRESS LOW FREQUENCY BAND VIA P.E.C.
376
COMPRESS (32 BIT FOR ALL HF BANDS)

FIG. 17

FIG. 18


344
n
380
n-2
HEADER
LL
HL
LH
HH
HL
LH
HH
...
342
n-1
378
346
348

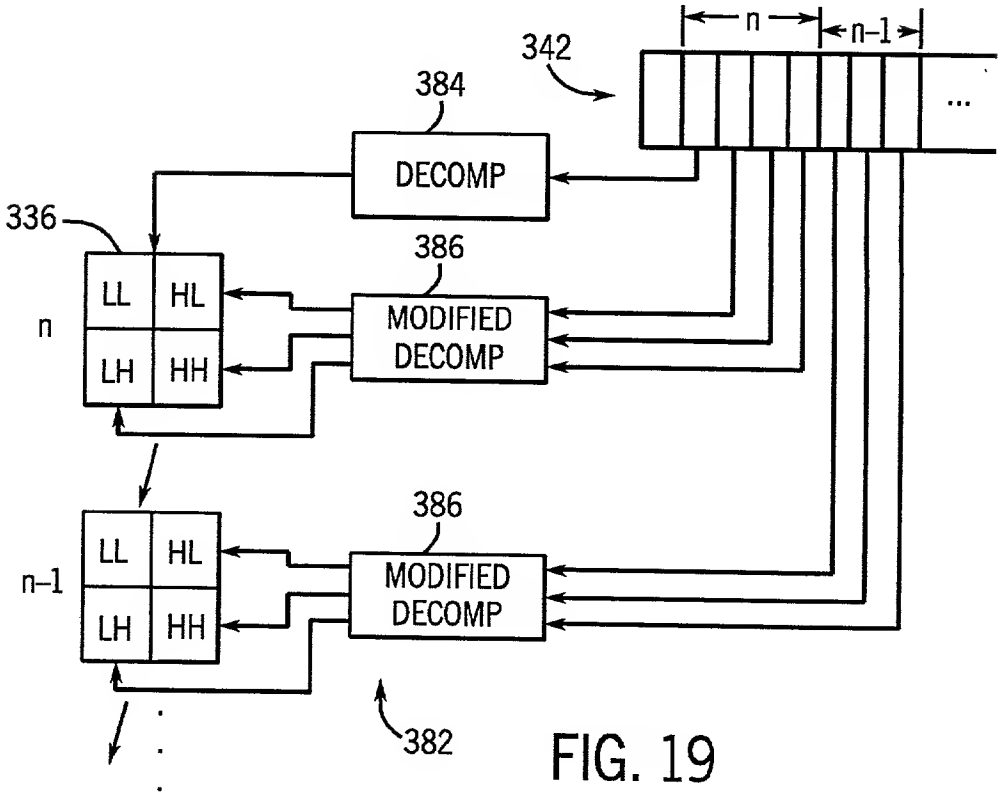

n
n-1
342
384
DECOMP
336
386
LL
HL
n
LH
HH
MODIFIED
DECOMP
386
LL
HL
n-1
LH
HH
MODIFIED
DECOMP
382

FIG. 19

FIG. 20

LEVEL	ROWS	COLS	COMPRESSED BYTES	EFF COMP RATIO
5	64	79	5652	1811:1
4	128	157	13780	526:1
3	256	313	49868	147:1
2	512	625	186128	40:1
1	1024	1250	724560	10:1
0	2048	2500	2929860	2.6:1

388

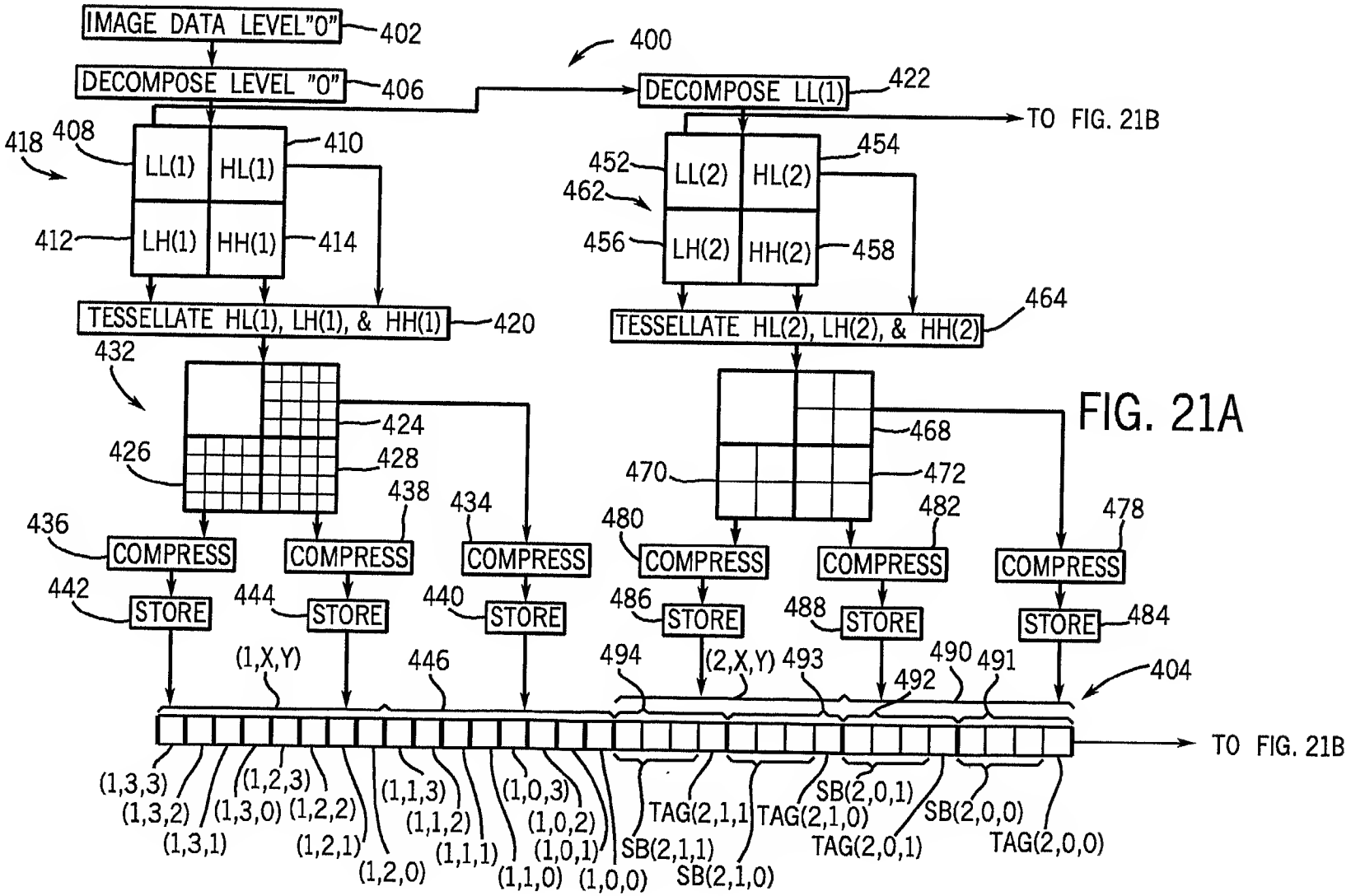


IMAGE DATA LEVEL"0"
402
400
DECOMPOSE LEVEL "0"
406
DECOMPOSE LL(1)
422
TO FIG. 21B
418
408
LL(1)
HL(1)
410
LH(1)
HH(1)
412
414
452
LL(2)
HL(2)
454
462
LH(2)
HH(2)
456
458
TESSELLATE HL(1), LH(1), & HH(1)
420
TESSELLATE HL(2), LH(2), & HH(2)
464
432
424
426
428
468
470
472
438
434
436
COMPRESS
480
482
478
442
STORE
444
440
486
488
484
(1,X,Y)
446
494
(2,X,Y)
493
490
491
492
404
TO FIG. 21B
(1,3,3)
(1,3,2)
(1,3,1)
(1,3,0)
(1,2,3)
(1,2,2)
(1,2,1)
(1,2,0)
(1,1,3)
(1,1,2)
(1,1,1)
(1,1,0)
(1,0,3)
(1,0,2)
(1,0,1)
(1,0,0)
SB(2,1,1)
SB(2,1,0)
TAG(2,1,1
TAG(2,1,0)
SB(2,0,1)
TAG(2,0,1)
SB(2,0,0)
TAG(2,0,0)

FIG. 21A

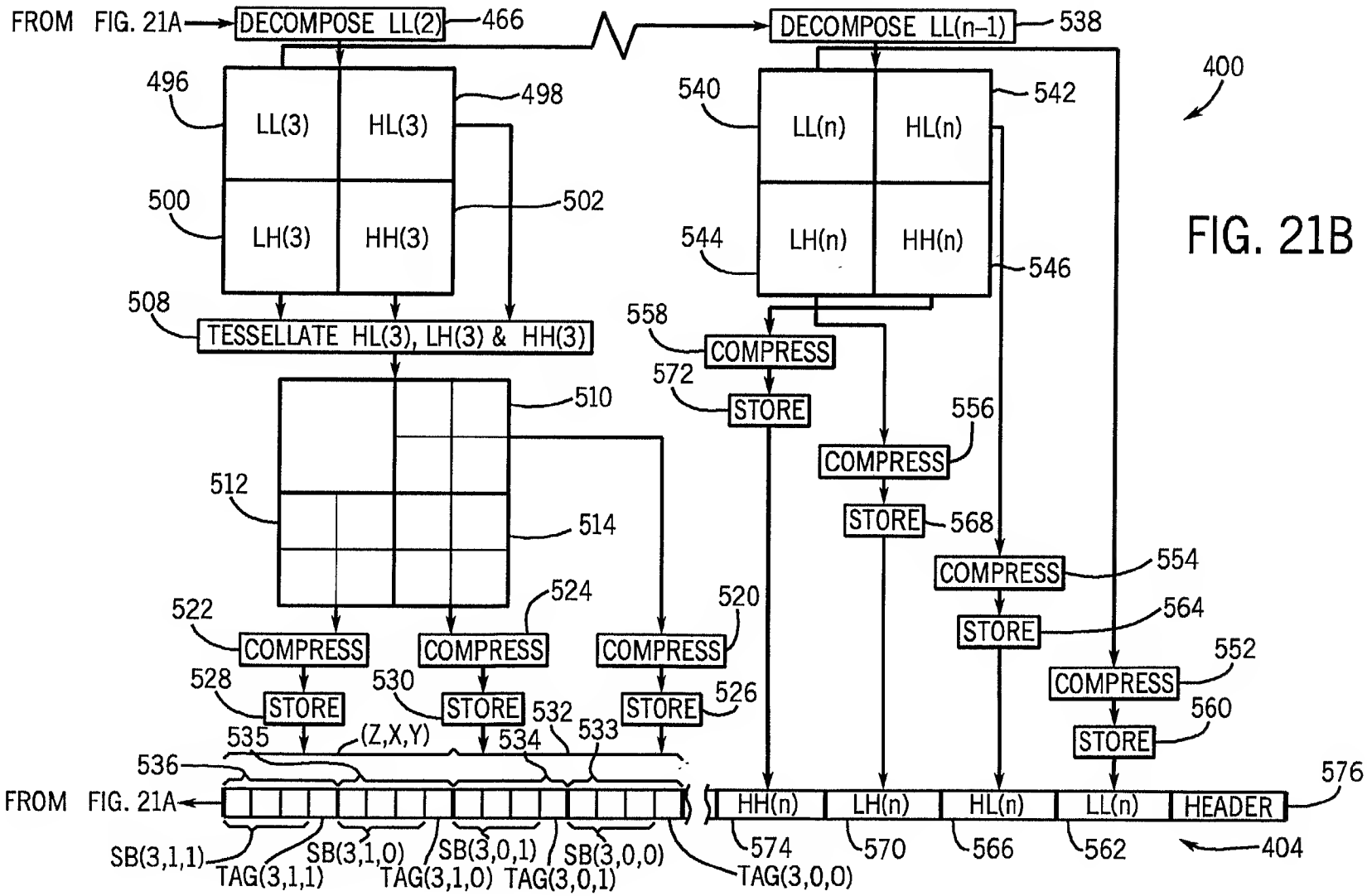

FROM FIG. 21A
DECOMPOSE LL(2)
466
DECOMPOSE LL(n–1)
538
400
496
LL(3)
HL(3)
498
540
LL(n)
HL(n)
542
500
LH(3)
HH(3)
502
544
LH(n)
HH(n)
546
508
TESSELLATE HL(3), LH(3) & HH(3)
558
COMPRESS
572
STORE
556
COMPRESS
510
512
514
STORE
568
554
COMPRESS
564
STORE
522
COMPRESS
524
COMPRESS
520
COMPRESS
552
COMPRESS
528
STORE
530
STORE
532
533
526
STORE
560
STORE
535
(Z,X,Y)
534
536
576
FROM FIG. 21A
HH(n)
LH(n)
HL(n)
LL(n)
HEADER
SB(3,1,1)
SB(3,1,0)
SB(3,0,1)
SB(3,0,0)
574
570
566
562
404
TAG(3,1,1)
TAG(3,1,0)
TAG(3,0,1)
TAG(3,0,0)

FIG. 21B

FIG. 22A

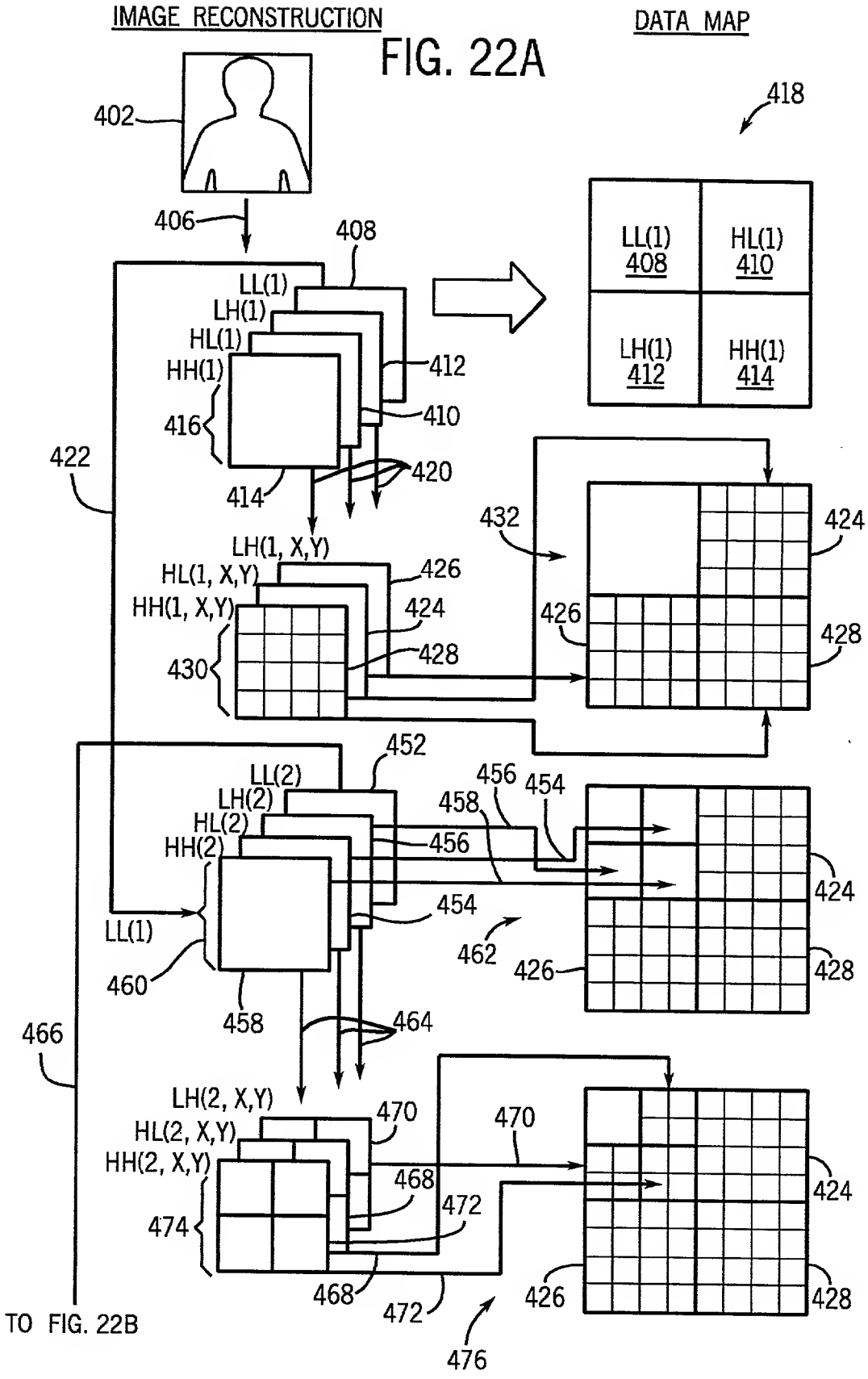


IMAGE RECONSTRUCTION
DATA MAP
402
406
408
418
LL(1)
LH(1)
HL(1)
HH(1)
412
410
416
420
414
422
LL(1) 408
HL(1) 410
LH(1) 412
HH(1) 414
LH(1, X,Y)
HL(1, X,Y)
HH(1, X,Y)
426
424
428
430
432
424
426
428
452
LL(2)
LH(2)
HL(2)
HH(2)
456
458
454
LL(1)
460
462
424
426
428
458
464
466
LH(2, X,Y)
HL(2, X,Y)
HH(2, X,Y)
470
470
468
472
474
424
426
428
468
472
476
TO FIG. 22B

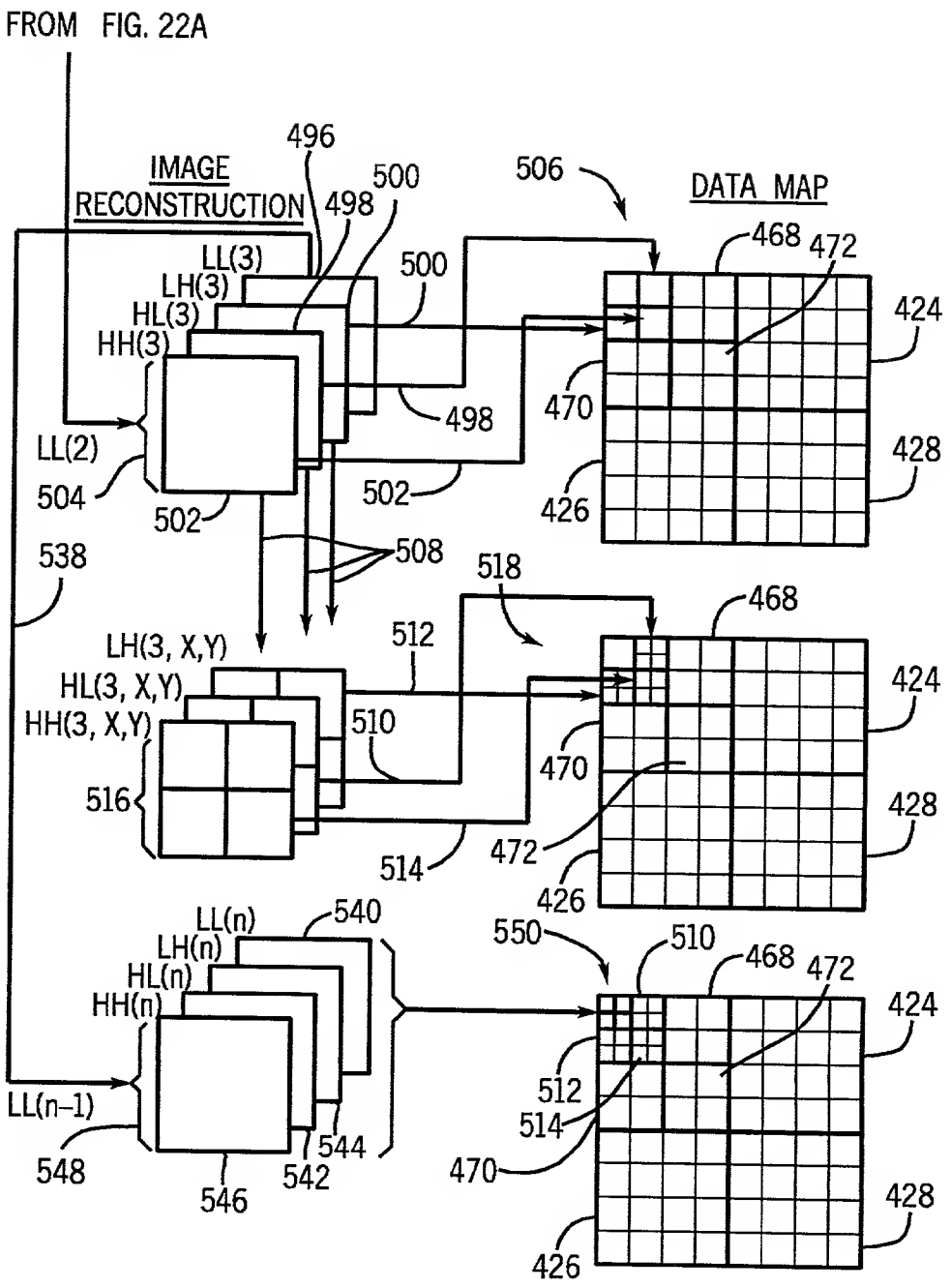

FROM FIG. 22A
IMAGE RECONSTRUCTION
496
498
500
506
DATA MAP
LL(3)
LH(3)
HL(3)
HH(3)
LL(2)
504
502
468
472
424
470
428
426
538
508
518
LH(3, X,Y)
HL(3, X,Y)
HH(3, X,Y)
512
510
516
514
LL(n)
LH(n)
HL(n)
HH(n)
LL(n-1)
540
550
544
542
546
548

FIG. 22B

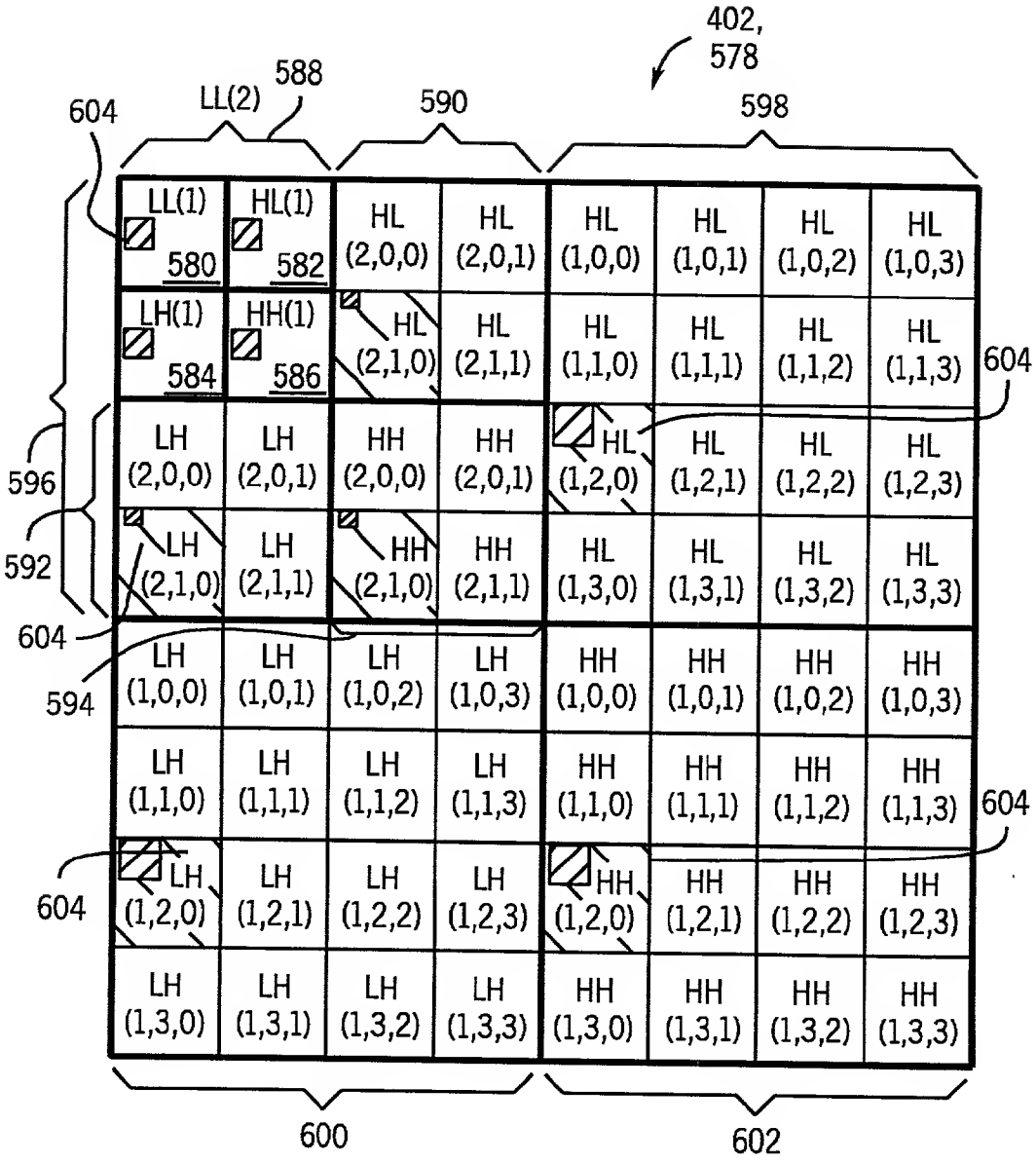

402,
578
588
LL(2)
590
598
604
LL(1)
580
HL(1)
582
HL
(2,0,0)
HL
(2,0,1)
HL
(1,0,0)
HL
(1,0,1)
HL
(1,0,2)
HL
(1,0,3)
LH(1)
584
HH(1)
586
HL
(2,1,0)
HL
(2,1,1)
HL
(1,1,0)
HL
(1,1,1)
HL
(1,1,2)
HL
(1,1,3)
604
596
LH
(2,0,0)
LH
(2,0,1)
HH
(2,0,0)
HH
(2,0,1)
HL
(1,2,0)
HL
(1,2,1)
HL
(1,2,2)
HL
(1,2,3)
592
LH
(2,1,0)
LH
(2,1,1)
HH
(2,1,0)
HH
(2,1,1)
HL
(1,3,0)
HL
(1,3,1)
HL
(1,3,2)
HL
(1,3,3)
604
LH
(1,0,0)
LH
(1,0,1)
LH
(1,0,2)
LH
(1,0,3)
HH
(1,0,0)
HH
(1,0,1)
HH
(1,0,2)
HH
(1,0,3)
594
LH
(1,1,0)
LH
(1,1,1)
LH
(1,1,2)
LH
(1,1,3)
HH
(1,1,0)
HH
(1,1,1)
HH
(1,1,2)
HH
(1,1,3)
604
604
LH
(1,2,0)
LH
(1,2,1)
LH
(1,2,2)
LH
(1,2,3)
HH
(1,2,0)
HH
(1,2,1)
HH
(1,2,2)
HH
(1,2,3)
LH
(1,3,0)
LH
(1,3,1)
LH
(1,3,2)
LH
(1,3,3)
HH
(1,3,0)
HH
(1,3,1)
HH
(1,3,2)
HH
(1,3,3)
600
602

FIG. 23

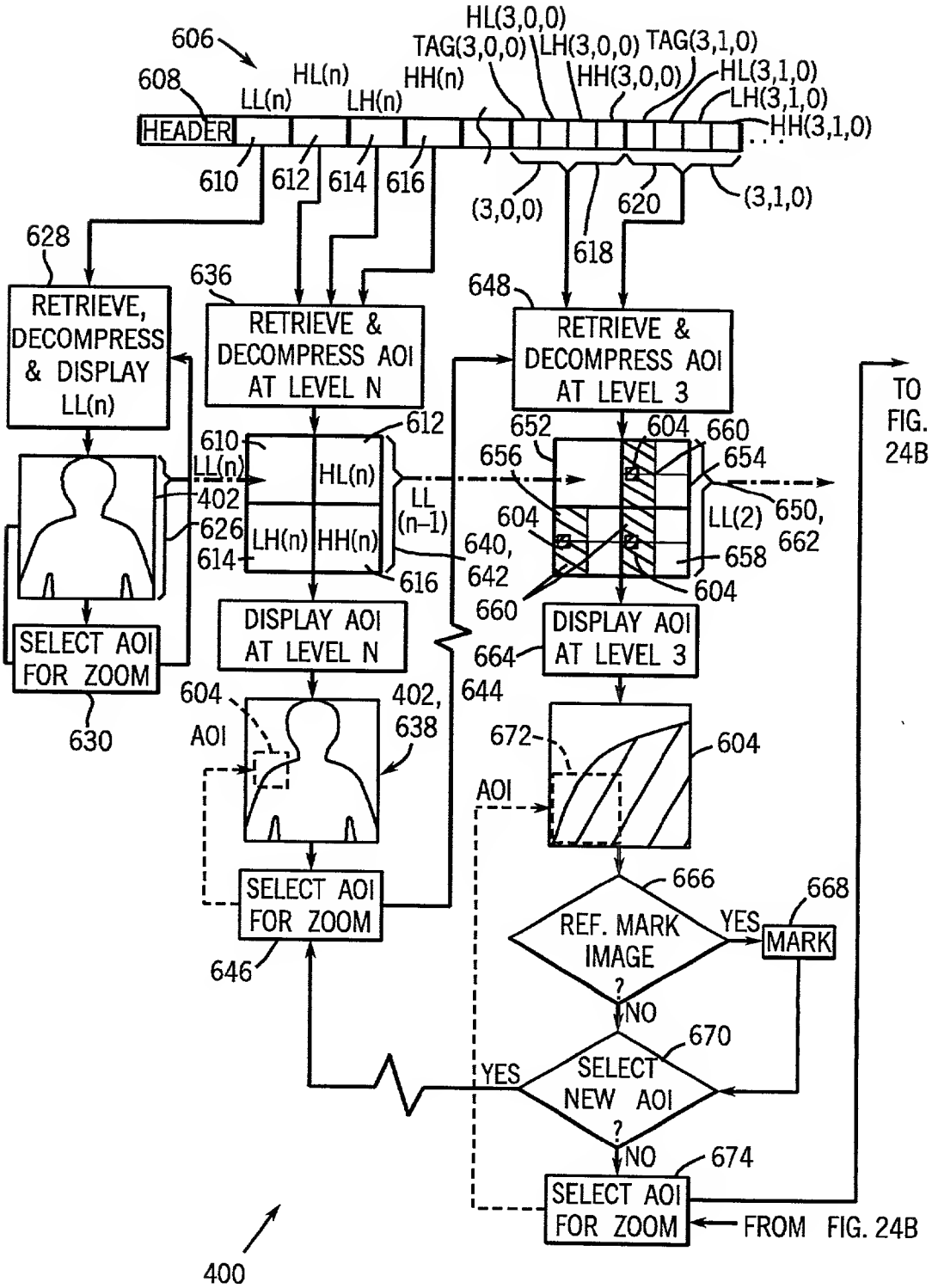

606
608
HEADER
LL(n)
HL(n)
LH(n)
HH(n)
HL(3,0,0)
TAG(3,0,0)
LH(3,0,0)
TAG(3,1,0)
HH(3,0,0)
HL(3,1,0)
LH(3,1,0)
HH(3,1,0)
610
612
614
616
(3,0,0)
618
620
(3,1,0)
628
RETRIEVE, DECOMPRESS & DISPLAY LL(n)
636
RETRIEVE & DECOMPRESS AOI AT LEVEL N
648
RETRIEVE & DECOMPRESS AOI AT LEVEL 3
TO FIG. 24B
402
626
LL(n)
HL(n)
LH(n)
HH(n)
LL (n–1)
652
656
604
660
654
650, 662
LL(2)
640, 642
658
SELECT AOI FOR ZOOM
630
DISPLAY AOI AT LEVEL N
DISPLAY AOI AT LEVEL 3
664
644
AOI
402, 638
672
SELECT AOI FOR ZOOM
646
666
REF. MARK IMAGE
YES
668
MARK
NO
670
SELECT NEW AOI
674
SELECT AOI FOR ZOOM
FROM FIG. 24B
400

FIG. 24A

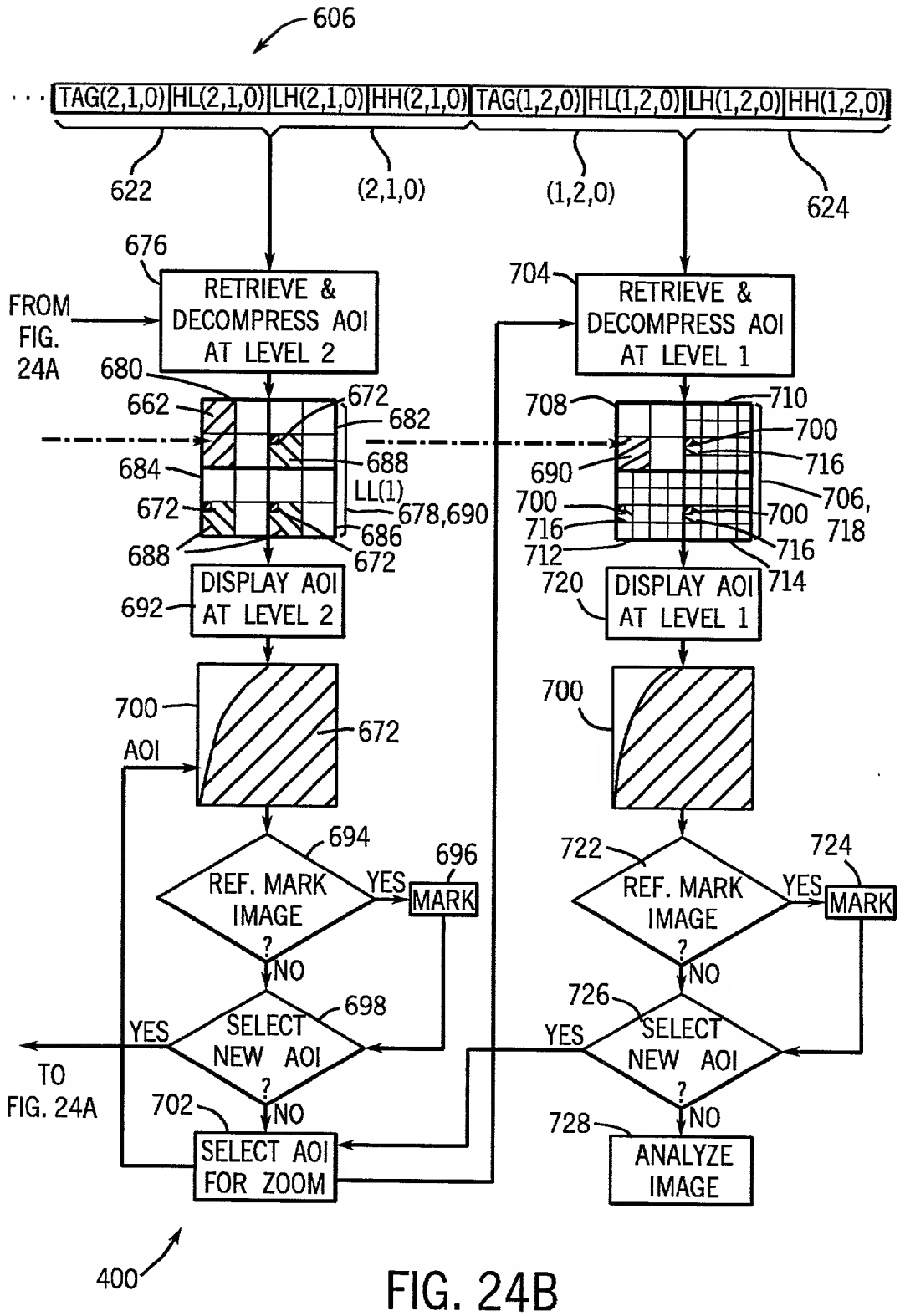

606
TAG(2,1,0) HL(2,1,0) LH(2,1,0) HH(2,1,0) TAG(1,2,0) HL(1,2,0) LH(1,2,0) HH(1,2,0)
622
(2,1,0)
(1,2,0)
624
676
RETRIEVE & DECOMPRESS AOI AT LEVEL 2
FROM FIG. 24A
680
662
672
682
684
688
LL(1)
672
678,690
686
688
672
DISPLAY AOI AT LEVEL 2
692
700
AOI
672
694
REF. MARK IMAGE
YES
696
MARK
?
NO
698
YES
SELECT NEW AOI
?
NO
TO FIG. 24A
702
SELECT AOI FOR ZOOM
704
RETRIEVE & DECOMPRESS AOI AT LEVEL 1
708
710
700
716
690
706, 718
700
700
716
716
712
716
720
DISPLAY AOI AT LEVEL 1
714
700
722
REF. MARK IMAGE
YES
724
MARK
?
NO
726
YES
SELECT NEW AOI
?
NO
728
ANALYZE IMAGE
400

FIG. 24B

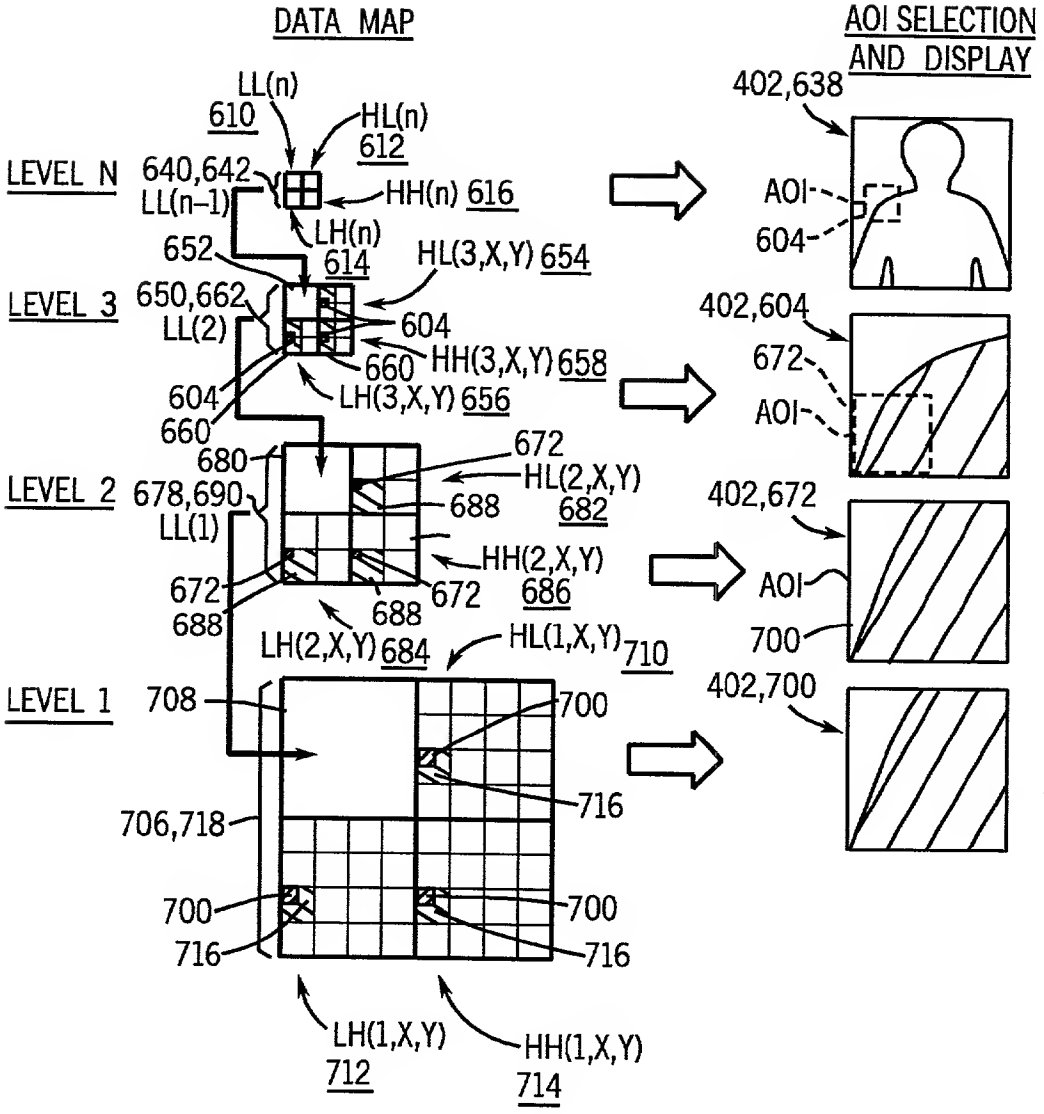

DATA MAP
AOI SELECTION AND DISPLAY
LL(n) 610
HL(n) 612
LEVEL N
640,642 LL(n-1)
HH(n) 616
LH(n) 614
652
HL(3,X,Y) 654
LEVEL 3
650,662 LL(2)
604
660
HH(3,X,Y) 658
LH(3,X,Y) 656
604
660
680
672
HL(2,X,Y) 682
LEVEL 2
678,690 LL(1)
688
HH(2,X,Y) 686
672
688
672
688
LH(2,X,Y) 684
HL(1,X,Y) 710
LEVEL 1
708
700
716
706,718
700
700
716
716
LH(1,X,Y) 712
HH(1,X,Y) 714
402,638
AOI
604
402,604
672
AOI
402,672
AOI
700
402,700

FIG. 25

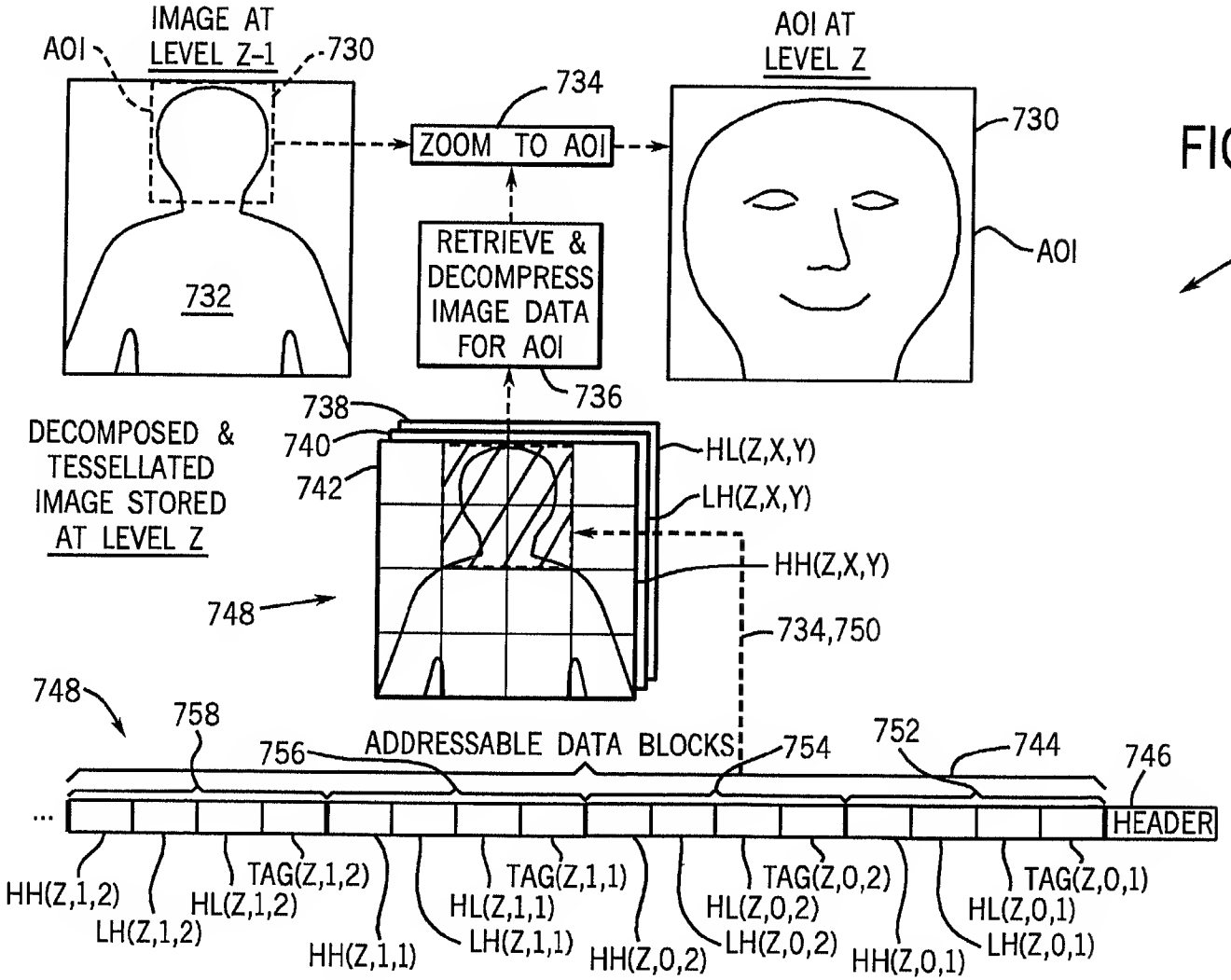


IMAGE AT LEVEL Z-1
AOI
730
732
734
ZOOM TO AOI
RETRIEVE & DECOMPRESS IMAGE DATA FOR AOI
736
AOI AT LEVEL Z
730
AOI
400
DECOMPOSED & TESSELLATED IMAGE STORED AT LEVEL Z
738
740
742
HL(Z,X,Y)
LH(Z,X,Y)
HH(Z,X,Y)
748
734,750
748
758
756
ADDRESSABLE DATA BLOCKS
754
752
744
746
HEADER
TAG(Z,1,2)
TAG(Z,1,1)
TAG(Z,0,2)
TAG(Z,0,1)
HH(Z,1,2)
HL(Z,1,2)
LH(Z,1,2)
HH(Z,1,1)
HL(Z,1,1)
LH(Z,1,1)
HH(Z,0,2)
HL(Z,0,2)
LH(Z,0,2)
HH(Z,0,1)
HL(Z,0,1)
LH(Z,0,1)

FIG. 26

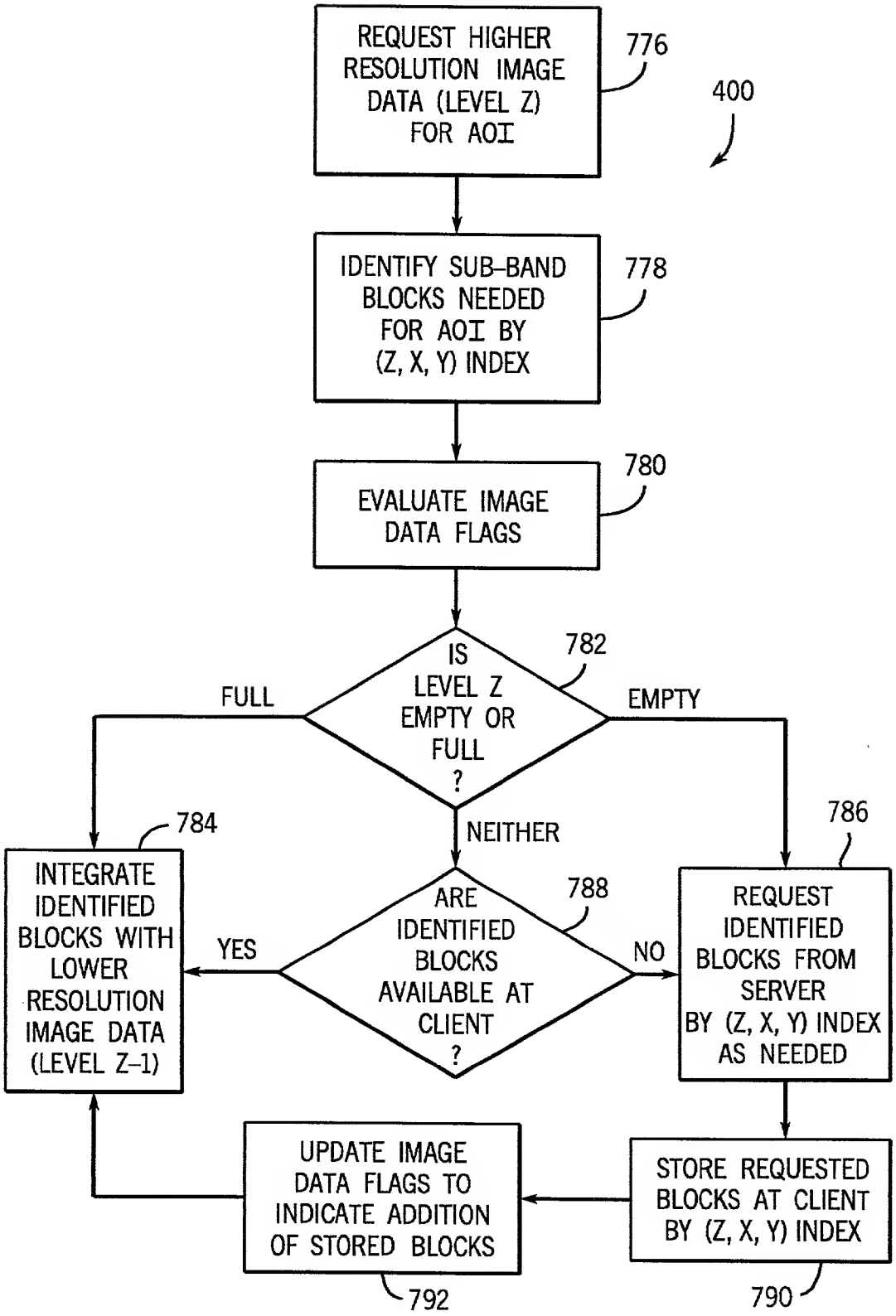

REQUEST HIGHER RESOLUTION IMAGE DATA (LEVEL Z) FOR AOI
776
400
IDENTIFY SUB-BAND BLOCKS NEEDED FOR AOI BY (Z, X, Y) INDEX
778
EVALUATE IMAGE DATA FLAGS
780
IS LEVEL Z EMPTY OR FULL ?
782
FULL
EMPTY
NEITHER
INTEGRATE IDENTIFIED BLOCKS WITH LOWER RESOLUTION IMAGE DATA (LEVEL Z-1)
784
ARE IDENTIFIED BLOCKS AVAILABLE AT CLIENT ?
788
YES
NO
REQUEST IDENTIFIED BLOCKS FROM SERVER BY (Z, X, Y) INDEX AS NEEDED
786
UPDATE IMAGE DATA FLAGS TO INDICATE ADDITION OF STORED BLOCKS
792
STORE REQUESTED BLOCKS AT CLIENT BY (Z, X, Y) INDEX
790

FIG. 27